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Monetary policy and interest rates under inflation targeting in Australia and New Zealand

Hakan Berument[a] and Richard T. Froyen[b]*

[a]Department of Economics, Bilkent University, Ankara, Turkey; [b]Department of Economics, University of North Carolina, Chapel Hill, NC, USA

One advantage cited for formal inflation targeting is that by anchoring inflationary expectations this policy framework would aid in the pricing of long-term securities. Long-term interest rates would become less sensitive to temporary shocks to the economy including policy-induced changes in short-term interest rates. This paper examines the experience in this regard of New Zealand and Australia, two countries that have been inflation targeters for many years. Our results are consistent with inflationary expectations having become more firmly anchored after the move to inflation targeting in each country. There is no evidence that the credibility of the inflation-targeting regime in either country weakened during the recent world financial crisis.

Keywords: inflation targeting; monetary policy; long-term interest rate

1. Introduction

One often-cited advantage of inflation targeting is that 'with long-term inflationary expectations more firmly anchored, long-term interest rates might jump around a bit less, and businesses and investors might find it easier to draw up long-term contracts'.[1] With long-term inflationary expectations anchored by a credible inflation-targeting regime, rates would respond by less to temporary shocks to the economy including policy-induced changes in short-term interest rates. Australia and New Zealand adopted inflation-targeting regimes in 1994 and 1990, respectively. Here, we examine their experience to see if the above predictions are borne out.

The link between the response of long-term interest rates to changes in monetary policy and the anchoring of inflationary expectations has been an element in the debate in the United States over moving toward an inflation-targeting framework. Ben Bernanke has argued that, 'the apparently high sensitivity of long-term nominal interest rates to Fed actions suggests some uncertainty about the Fed's long-run inflation target'.[2]

More broadly, the study of the effects of monetary policy rates on long-term rates under inflation-targeting regimes is of interest for the question of whether inflation targeting matters. Studies such as Ball and Sheridan (2005), Ball (2011), Mishkin and Schmidt-Hebbel (2007), Dueker and Fischer (2006), and Levin, Natalucci, and Piger (2004) suggest answers ranging from 'IT (inflation targeting) has played a role in anchoring inflationary expectations and in reducing inflation persistence' (Levin *et al*., 2004) to 'thus on the heels of a decade of low global inflation, it has been hard to argue that formal

*Corresponding author. Email: froyen@email.unc.edu

inflation targets have led to any divergence between targeters and non-targeters in terms of inflation performance' (Dueker & Fischer, 2006).

The experience of New Zealand and Australia is of interest from several additional perspectives. New Zealand was regarded, at least for many years, as the strictest inflation-targeting nation. Australia was viewed as having, as Dueker and Fischer (2006) term it, 'a more nebulous charge to keep inflation at levels comparable with those of its major trading partners' (pp. 440−441).[3] Our estimates provide evidence on whether any differences in the targeting regimes had discernible effects on the relationship of long-term rates to the policy rate. Additionally, with regard to procedures, in April of 1999, the Reserve Bank of New Zealand shifted from an operating target of cash settlement balances to control of the overnight interbank cash rate. We examine whether this shift altered the relationship between monetary policy actions and long-term interest rates. Finally, the fact that the monetary policy rate in Australia and New Zealand has been unconstrained by the zero lower bound, allows us to extend the analysis to examine whether the world financial crisis in 2008 weakened the credibility of the inflation-targeting regime in each country as measured by the response of long-term rates to the policy rate.

To highlight a central conclusion, our statistical results indicate that the responses of longer term interest rates to changes in monetary policy rates declined in Australia and New Zealand following the introduction of inflation targeting − an indication that inflationary expectation became better anchored. Comparisons to the United States, a non-inflation targeter, do not show that these responses were smaller for the two inflation-targeting countries, as might be expected if inflationary expectations were better anchored. Our results are consistent with inflation-targeting regimes in Australia and New Zealand having resulted in inflationary expectations as well anchored as in the United States compared to less stable pre-inflation-targeting regimes.

The paper proceeds as follows. Section 2 provides background on the inflation-targeting regimes and variances of long-term interest rates in the two countries. Section 3 examines evidence from vector auto regressions (VARs). We test whether there were structural shifts in the coefficients in estimated VARs pre- versus post-adoption of inflation targeting in Australia and New Zealand. Also pre- and post-adoption of inflation targeting, we examine the effects on longer term interest rates from innovations in the policy rate in these countries as measured by impulse response functions. In Section 4, we use data from the days on which the central banks in Australia and New Zealand changed their policy rates to assess the effects of unanticipated changes in the policy rate on longer term interest rates. Section 5 concludes.

2.   Background and descriptive statistics

Table 1 shows the variance of 5- and 10-year government security rates for New Zealand and Australia. Data are monthly and variances are for selected time periods before and after the adoption of inflation targeting in each country.[4]

For New Zealand, the pre-inflation-targeting period is April 1985−January 1990 (Panel A; line 1). This is the period from the floating of the New Zealand dollar to the effective date of the Reserve Bank of New Zealand Act in February 1990, the beginning of formal inflation targeting. The period of inflation targeting is February 1990 to October 2012 (line 2). Statistics are also shown for several subperiods. The variance of both interest rates is lower in all the inflation-targeting periods relative to the pre-inflation-targeting period. The decline is greater for the inflation-targeting period cut-off in August 2008 just before the start of the world financial crisis.[5] Including the very low interest rate years

Table 1. Variance of 5-year and 10-year interest rates, selected periods.[a]

	5 year	10 year
Panel A: New Zealand		
April 1985−January 1990	5.72	4.12
February 1990−October 2012	3.70**	3.13*
February 1990−August2008	2.69***	2.64**
April 1999−October 2012	1.11***	0.64***
April 1999−August 2008	0.26***	0.20***
Panel B: Australia		
	5 year	10 year
April 1985−September 1994	7.56	5.51
October 1994−October 2012	1.93***	1.90***
October 1994−August 2008	1.55***	1.67***

[a]For Panels A and B, a two-tailed test for the equality of the variance of each interest rate for the particular inflation-targeting period versus the pre-inflation-targeting period is conducted. To save space, the test statistics are not reported but asterisks (*) are included to indicate whether post-IT period variances differ significantly from those for the pre-IT period. A rejection of equality is indicated at the 1% level by (***), at the 5% level by (**), and at the 10% level by (*).

that followed raises the variance. The Reserve Bank shifted from an operating target of cash settlement balances to control of the overnight interbank cash rate in April 1999. This change in operating procedures resulted in increased transparency.[6] Subperiods starting in April 1999 show markedly lower interest rate variances relative to the pre-inflationtargeting period.

As can be seen from Table 1 (as indicated by asterisks), a test of the equality of the variance of either interest rate in any of the inflation-targeting periods with that for the pre-inflation-targeting period rejects equality at least at the 0.10 level of significance, for many rates and periods at the 0.01 level.

Inflation targeting in Australia dates to Reserve Bank Governor Fraser's statement of 26 September 1994. Thus, for our comparison of variances of Australian interest rates pre-and post-adoption of inflation targeting (Panel B), we compare the period April 1985−September 1994 (line 1) to October 1994−October 2012 (line 2) as well as to the shorter period October 1994−August 2008 (line 3). For either of these inflation-targeting periods, the variance of the 5- and 10-year interest rate was substantially lower relative to the pre-inflation-targeting period. The hypothesis that the variance of either of the interest rates in either inflation-targeting period was equal to that in the pre-inflation-targeting period is rejected at the 0.01 level of significance.

The post-1990 period up until the world financial crisis was quite stable which may account for lower volatility in interest rates. Table 2 shows the variance of 10-year interest rates in seven OECD countries including New Zealand and Australia for April 1985−December 1995 compared to two later periods: January 1996−October 2012 and January 1996−August 2008. The variance of 10-year interest rates in all the countries in the table was lower for the later period when it ends in August 2008. With the later period extended to 2012, the results were mixed. It is also the case that the inflation-targeting countries in the comparison group do not show markedly greater declines than the United States.

Table 2. Variance of 10-year interest rates: selected countries.

	April 1985−December 1995	January 1996−October 2012	January 1996−August 2008
Australia	5.39	1.04	0.74
New Zealand	13.50	0.89	0.46
Canada	1.13	1.58	0.93
Sweden	2.45	2.30	1.55
Switzerland	0.86	0.75	0.32
United Kingdom	1.72	1.78	1.06
United States	1.54	1.63	0.81

The proportionate decline in the variance of the 10-year rate is largest for New Zealand and Australia for both breaks in the sample. Comparing 1985−1995 with 1996−2012, New Zealand and Australia go from having the highest variance of 10-year rate to the lowest variance with the exception of Switzerland.[7] Thus, the decline in volatility of interest rates in New Zealand and Australia does not appear to be due solely to world economic conditions. These two countries with high interest rate volatility converged to the less volatile countries whether the latter were inflation targeters or not.

3. VAR analysis

This section examines the implications of estimated VARs for effects on longer term interest rates resulting from innovations in monetary policy rates for Australia and New Zealand. We check for evidence of structural shifts in the coefficients of the estimated VARs following the adoption of inflation targeting in each country. We then examine effects on longer term rates from innovations in the policy rates as well as other macroeconomic shocks in these countries as measured by impulse response functions.

The relationship of these VAR estimates to the questions raised in the introduction is the following: if inflation targeting better anchors long-term inflationary expectations, innovations in the overnight cash rate should have less effect on the average of expected future short rates and thus on long-term rates. Thus, the volatility of long-term rates will be reduced. With better anchored inflationary expectations, long-term rates should also be less responsive to the nominal component of innovations in other macroeconomic variables.[8] Thus, the expectation is that if inflation targeting has better anchored inflationary expectations, we will observe statistically significant changes in the parameters of estimated VARs following the adoption of this policy regime. Most directly, we expect changes in impulse responses showing the effect on long-term rates from innovations in the monetary policy rate.[9]

3.1. Details of the VARs

3.1.1. Data and specification

The VARs for Australia and New Zealand each contain four variables: the overnight cash rate, a longer term interest rate (2 year, 5 year or 10 year), the exchange rate (value of the Australian or New Zealand dollar in US dollars), and an index of Australian or New Zealand commodity prices, measured in home currency (July 1986 = 100).[10] Interest rates are measured in percent. The exchange rate and commodity price variables are

entered as logarithmic first differences. The sample period runs from April 1985 to October 2012. Selected subsamples are also examined. Observations are monthly. Monthly dummy variables were included to account for seasonality.

3.1.2. *Tests for unit roots and co-integration*

Tests for unit roots were conducted on each data series. The tests were: the augmented Dickey−Fuller test, Elliott−Rothenberg−Stock-DF-GLS test, Phillips−Perron test, and Kwiatkowski−Phillip−Schmidt−Shin (KPSS) test. The null is presence of a unit root for the first three tests. The null is stationarity for the last test.

For New Zealand, for the logarithmic first difference of the exchange rate and commodity price series, the presence of a unit root is rejected, generally at the 0.01 level, by the first three tests in the sample period and all subsamples that we use. The null of stationarity is never rejected by the fourth (KPSS) test. We therefore assume these series are stationary.

The situation is less clear cut for the interest rate series (policy rate: 2-year, 5-year, and 10-year rates). The presence of a unit root cannot be rejected for at least two out of three unit root tests that we employ for all interest rates for all samples that we consider. For all samples, the null of stationarity is rejected by the KPSS test at least at the 0.10 level. Given the stronger support for the presence of a unit root we assume this to be the case.

For Australia, for log first differences of the exchange rate and commodity price series, a unit root is rejected at the 0.01 level by each of our three tests for all sample periods. Stationarity is not rejected by the KPSS test for any sample period. These series appear to be stationary. In the case of the interest rate series, for the inflation-targeting period a unit root is rejected in about 50% of the tests (three tests each across the four interest rates). Pre-inflation targeting a unit root is not rejected by any of our three tests for any interest rate. Stationarity is, however, rejected by the KPSS test in all sample periods. Thus, the presence of a unit root must be considered as a possibility for the interest rate series.[11]

Because some of the series may contain unit roots, we test for co-integration. Table 3 reports the Johansen co-integration test results for the null that there are no co-integrating vectors. The reported *p*-values in the table indicate clear rejection of the null of no co-integration at the 0.01 level for all samples and all interest rates in New Zealand and Australia. This is consistent with a co-integrating vector between the two possibly non-stationary variables − the interest rates in each of our VARs. Sims, Stock, and Watson (1990) and Lutkepohl and Reimers (1992) argue that if part of a system consists of series that contain unit roots but the system is co-integrated, as appears to be the case with our data, VAR estimates will be consistent.

3.1.3. *Tests for structural breaks*

If the move to inflation targeting caused long-term interest rates to become less sensitive to changes in the monetary policy rate as well as other shocks, we would expect the coefficients in the VARs we estimate to differ pre- and post-adoption of inflation targeting. To test for this, we perform several of Chow's structural break tests.[12] The results are shown in Table 4 for Australia and New Zealand. The tests are for a structural break pre- and post-adoption of inflation targeting in each country. For New Zealand, we also test for a structural break within the inflation-targeting period when the Reserve Bank

Table 3. Co-integration tests.[a]

New Zealand			Australia		
Int. rate	Test stat.	*p*-value	Int. rate	Test stat.	*p*-value
April 1985−October 2012			April 1985−October 2012		
2 year	224.3703	0.0001	2 year	266.7206	0.0001
5 year	210.5875	0	5 year	270.8262	0.0001
10 year	199.1738	0	10 year	257.8049	0.0001
April 1985−January 1990			April 1985−September 1994		
2 year	110.8073	0			
5 year	104.2254	0	5 year	99.7176	0
10 year	102.2347	0	10 year	93.32081	0
February 1990−October 2012			October 1994−October 2012		
2 year	167.5752	0	2 year	266.7206	0.0001
5 year	156.6077	0	5 year	238.1483	0.0001
10 year	149.1558	0	10 year	235.9661	0.0001
February 1990−March 1999					
2 year	99.23902	0			
5 year	97.29524	0			
10 year	95.81661	0			
April 1999−October 2012					
2 year	134.3311	0			
5 year	127.2561	0			
10 year	127.1266	0			

[a]Johansen co-integration test for the null of zero co-integrating vectors.

switched from cash settlement balances to the overnight interbank cash rate as an operating target in April 1999. For each test, there are two VARs: one where the long-term interest rate is the 5-year rate and one with the 10-year rate. The table shows the significance level (*p*-value) for a break between the two periods in the test.

The first test is for a structural break in the multi-equation VAR system (the first column). For each break point, evidence of a structural break is strong (*p*-value 0.000).

Table 4. Structural break tests.[a]

Country	Break		System		Long rate		Policy rate	
			F-stat	*p*-value	*F*-stat	*p*-value	*F*-stat	*p*-value
Australia	October 1994	5 year	518.7485	0.0000	8.1012	0.0000	2.6313	0.0004
		10 year	535.5599	0.0000	1.1835	0.2739	2.4458	0.0012
New Zealand	February 1990	5 year	255.5497	0.0000	2.1975	0.0042	7.6601	0.0000
		10 year	242.5473	0.0000	2.0220	0.0097	8.0134	0.0000
New Zealand	April 1999[b]	5 year	306.5292	0.0000	1.5846	0.0664	1.5195	0.0857
		10 year	302.7227	0.0000	1.5485	0.0765	1.4623	0.1064

[a]Cells in the table are the *F*-statistics and *p*-values giving the marginal significance level from a Chow test for the equality between sets of coefficients from two multi-equation VARs or two single-equation linear regressions.
[b]Sample starts in February 1990 rather than April 1985 as in the other samples.

The other two tests are for changes in the coefficients in individual equations in the VAR. The first is for the equation for the long-term rate in each VAR (the second column). For Australia, the test shows evidence of a significant break for the equation for the 5-year but not for the 10-year rate. For New Zealand, there is evidence of a significant break at the 0.01 level pre- and post-inflation targeting for both long-term rates. For the break in New Zealand, at the date of the change in operating target, the test indicating a break is significant only at the 0.10 level for the 5- and 10-year rate equations.

The second single equation test is for the policy rate equation in each country (the third column). The Chow test indicates a break at the 0.01 level in both countries pre- versus post- adoption of inflation targeting for VARs containing either the 5-year or 10-year interest rates. There is a weaker evidence of a break for New Zealand with the change in operating target in 1999.

The test statistics in Table 4 suggest significant changes in the coefficients in VARs pre-and post-adoption of inflation targeting in both Australia and New Zealand.

3.2. *Impulse response functions*

Impulse response functions are computed using the method of Pesaran and Shin (1998) to identify the shocks in the VAR. These generalized impulse response functions are insensitive to the ordering of the variables. For the VARs, the lag length chosen by the Bayesian information criterion is 1.[13] The impulse responses are to a one-percentage point change in the level of an interest rate or one percent change in the exchange rate or commodity price index. In the figures, the impulse response function is the solid line; dotted lines indicate confidence bands (plus /minus two standard deviations).[14]
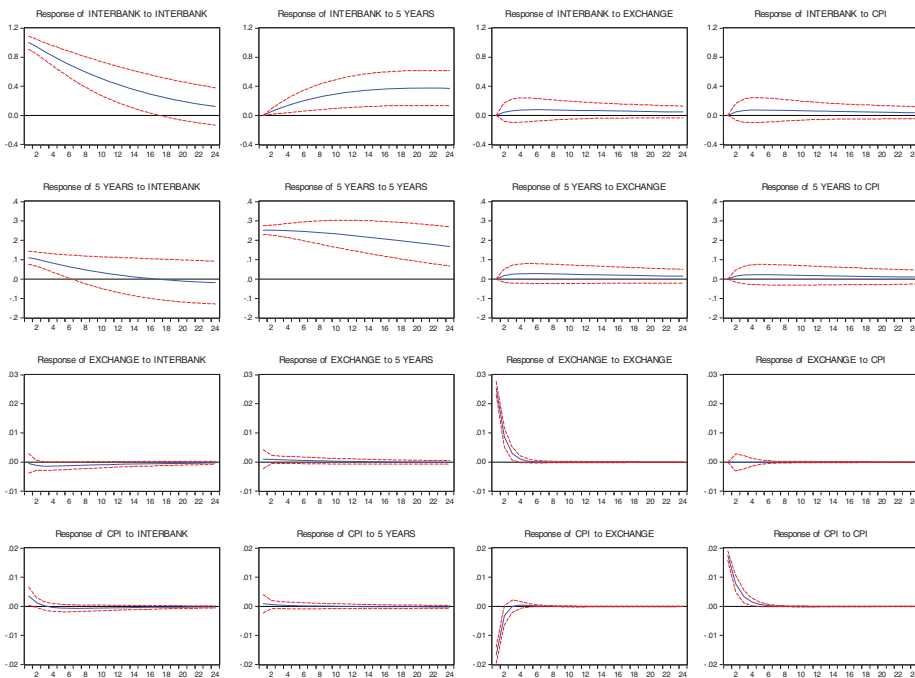

Figure 1.   Impulse response functions: New Zealand, 5-year rate, February 1990−October 2012.
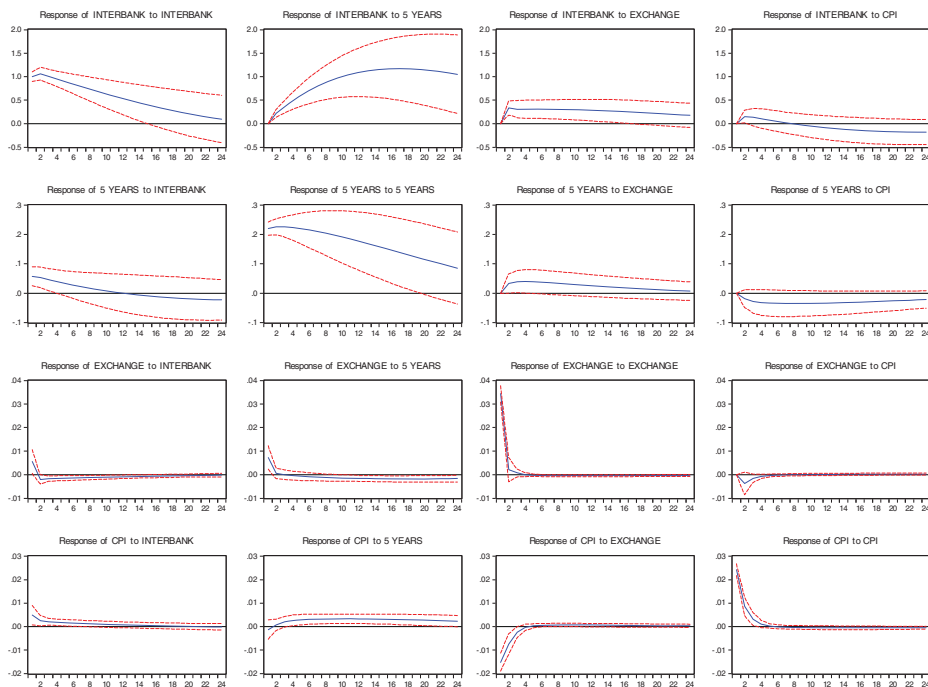
Figure 2.   Impulse response functions: Australia, 5-year rate, October 1994−October 2012.

Representative impulse response functions for New Zealand and Australia are shown in Figures 1 and 2. For each country, the VAR is estimated from the beginning of inflation targeting to October 2012. Thus, the starting point for New Zealand is February 1990 and October 1994 for Australia. In each figure, the long-term interest rate is the 5-year rate. Out interest is primarily in the response of the longer term interest rates to the policy rate − the row 2−column 1 cell of each panel. Thus, for other sample periods and maturities we show only that panel.

Some comments on the complete set of impulse response functions as shown in Figures 1 and 2 are merited. For New Zealand (Figure 1), the effects of a one-percentage point shock in policy rate (interbank rate) on the exchange rate and commodity price measures are short-lived. In the case of the exchange rate, the effect of the interbank rate is negative but insignificant.[15] The commodity price index responds positively but briefly and with marginal significance.[16] With respect to the main variable of interest, Figure 1 shows that the 5-year interest rate rises initially by 0.10 percentage points in response to a one percentage point increase in the interbank rate. The 5-year rate returns to its initial level after approximately 15 months; the response is significant for approximately six months. Impulse response functions for Australia are shown in Figure 2. The pattern is similar to that for New Zealand. The initial response of the 5-year rate to the policy rate is smaller, approximately 0.05 percentage points per one percentage point. The response dies out after approximately 12 months (significant for 5 months).

Two features of these impulse responses are of interest. First, the interbank rate process shows considerable persistence (the 1×1 panel of each figure). Second, there is a strong response of the interbank rate to the 5-year rate (1×2 panel of each figure).
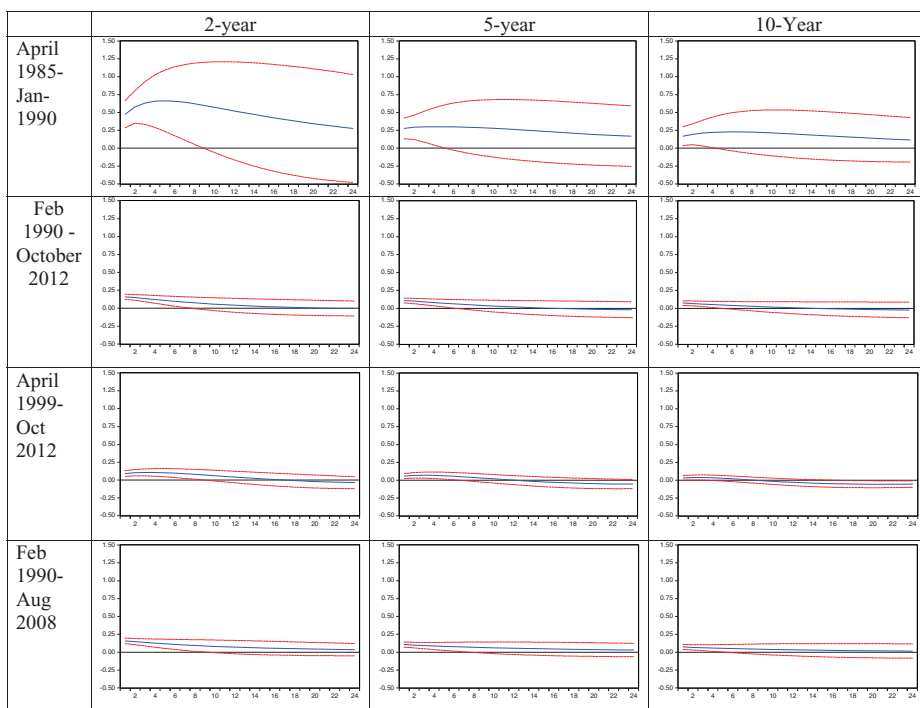
Figure 3. Impulse response functions: market rates to OCR: selected time periods, New Zealand.
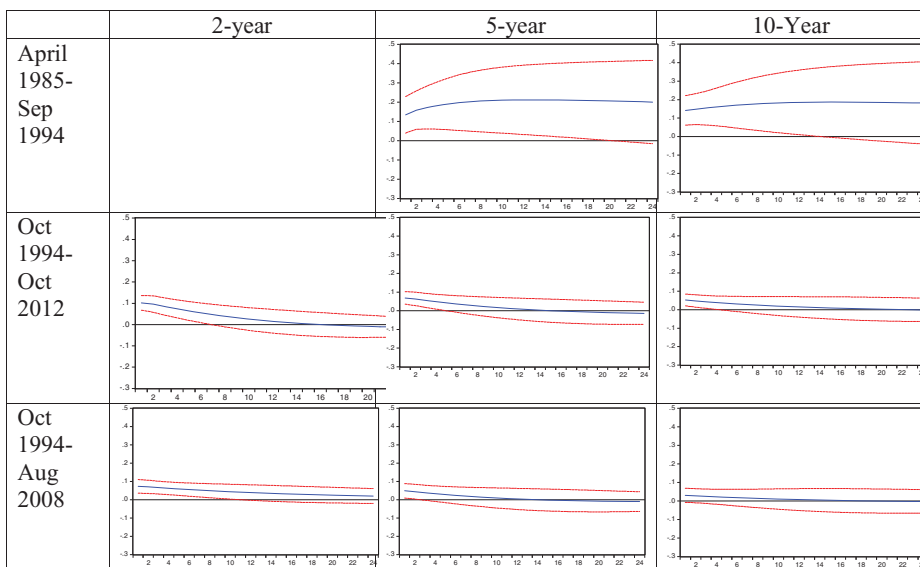

Figure 4.   Impulse response functions: market rates to interbank rate: selected time periods for Australia.
Note: Data for the 2-year interest rate does not go far enough back to estimate the VAR for the pre-inflation-targeting period. Thus, the 1×1 cell in the figure is blank.

3.3.   Effects on long-term rates of shocks to the policy rate

Figures 3 and 4 show impulse response functions for several time periods for 2-, 5-, and 10-year interest rates.

3.3.1.   New Zealand

For New Zealand, in addition to the 1990−2012 period in Figure 1, Figure 3 shows impulse responses for the pre-inflation-targeting period (April 1985−January 1990), for the period of inflation targeting after the adoption of the overnight cash rate as the short-run operating target (April 1999−October 2012) and a period (February 1990−August 2008) that ends with the onset of the world financial crisis.

The impulse response functions reveal two patterns. First, moving across a row of the figure, we see that as the term to maturity increases (from 2 to 5 to 10 years) the response of the interest rate to a one-percentage point shock to the policy rate declines. Second, for the first three rows, as we look down a column (going from pre-IT to the whole IT period to post-1999), the response of longer term interest rates to a shock declines at each maturity. In the case of the 5-year rate, for example, the (initial) response to a one-percentage point change in the policy rate is approximately: 0.25 percentage points pre-inflation targeting; 0.10 percentage points for the February 1990−October 2012 period; and 0.05 percentage points for the April 1999−October 2012 period (following the change in operating procedure).

The last row of Figure 3 shows the result of cutting the inflation-targeting sample off in August 2008 to exclude the world financial crisis and recession. The impulse response functions do not indicate a substantial change in the magnitude of the responses of longer term interest rates to a change in the policy rate.

3.3.2.   Australia

Figure 4 shows responses of three longer term interest rates to a one-percentage point shock in the policy (interbank) rate in Australia. The panels in the first two rows of the figure compare periods before (April 1985−September 1994) and after (October 1994−October 2012) the adoption of inflation targeting. The pattern is similar to that for New Zealand. The response of longer term interest rates to the policy rate declines with term to maturity and is markedly smaller post-adoption of inflation targeting.[17] The panels in the third row of the figure show impulse responses where the inflation-targeting period is cut off at the start of the world financial crisis in fall 2008. This has no discernible effect on the magnitude of the responses of long-term interest rates to changes in the policy rate.

A comparison of Figures 3 and 4 indicates that for the inflation-targeting periods the responses of longer term interest rates to the monetary policy rate in the two countries were of roughly the same magnitude and duration, with the responses for Australia slightly smaller.

3.4.   Comparison to previous US VAR analysis

How do the impulse response functions in this section compare with impulse response functions from previous studies for the United States, a non-inflation-targeting country? Summarizing the US results Evans and Marshall (1998) state, 'A contractionary policy shock induces a pronounced but short-lived response of short-term rates. The response declines monotonically with maturity; long-term rates are virtually unaffected.' An

additional finding from VAR analysis for the United States is that the estimated responses of long-term interest rates to innovations in the federal funds rate are lower for the post-1987 period relative to pre-1979 and still lower for the post-1994 years (Berument & Froyen, 2006, 2009). The Federal Reserve's greater emphasis on inflation post-1979 and greater transparency in the 1990s are possible reasons for this decline, reflecting greater anchoring of inflationary expectations. Overall, VAR estimates do not show larger responses of long-term interest rates to the innovations in the policy rate in the United States relative to Australia or New Zealand.[18]

4. Effects of policy rate surprises

In this section, an alternative method is used to examine the effects that unanticipated changes in monetary policy rates have on longer term rates.

4.1. Measuring policy rate surprises for New Zealand and Australia

To study the effect of unanticipated (or surprise) changes in monetary policy rates, a method is needed to distinguish between anticipated and unanticipated actions. For United States monetary policy Kuttner (2001) used data from the federal funds futures market to measure market anticipations of policy actions. An equivalent futures market does not exist for New Zealand. Cochrane and Piazzesi (2002) and Ellingsen, Söderström, and Masseng (2004) measure the unanticipated (or surprise) component of a policy action as the change in a 30-day interest rate from just before to just after the change in the policy rate. We follow this approach for New Zealand and Australia.[19] The logic motivating this measure is that the 30-day rate, which reflects expectations of overnight rates for the next 30 days and a term premium, will change with only the unanticipated component of changes in the policy rate.

Reserve Bank of New Zealand policy actions are announced in the morning before financial markets open.[20] Therefore, we measure the surprise component of a change in the Reserve Bank's official cash rate (OCR) (ΔRU) by the change in the 30-day rate on the day (t) of the policy announcement (day(t) − day(t − 1)).[21] We then regress the change in each of the longer term rates (ΔRL) on this measure of the policy surprise. The same procedure is used to measure policy rate surprises for Australia. The timing is the same: the change in the 30-day rate on the day of the policy announcement from the previous day because the Reserve Bank announces a change well before the close of the market.

Thus, for both countries we estimate

$$\Delta RL_t = a + b\Delta RU_t + \varepsilon_t. \tag{1}$$

Results are shown in Table 5.

4.2. Estimates for New Zealand

Estimates for New Zealand are shown in panel A of Table 5. The estimates in column 1 are for the sample period April 1999−August 2013, the whole period during which the official cash rate was the operating target. The sample period for the estimates in column 2 also starts in April 1999 but ends in August 2008.

Table 5. Effect on long-term rates of an unexpected one-percentage point change in policy rate.[a]

	Panel A: New Zealand		Panel B: Australia		Panel C: United States
	April 1999–Aug 2013	April 1999–Aug 2008	April 1999–Aug 2013	April 1999–Aug 2008	April 1999–Aug 2008
	(1)	(2)	(3)	(4)	
90 days	0.967	0.943	0.861	0.876	0.802
	(15.06)	(14.36)[b]	(10.86)	(11.75)	(12.37)
1 year	0.832	0.907	0.828	0.811	0.241
	(6.89)	(6.78)	(6.56)	(6.86)	(2.59)
2 year	0.682	0.701	0.657	0.630	0.079
	(7.32)	(6.04)	(3.50)	(6.07)	(0.71)
5 year	0.438	0.407	0.349	0.310	0.125
	(6.18)	(4.26)	(1.93)	(1.58)	(1.06)
10 year	0.249	0.229	0.138	0.068	0.162
	(4.25)	(2.97)	(0.80)	(0.38)	(1.29)
Number of observations	41	34	44	23	42

[a]As explained in the text the unexpected component of a change in policy rate is measured by its same day effect on the 30-day bill rate.
[b]The t-statistic for coefficient is in parentheses.

Table 6. Data Sources.

Data sources	The sources and descriptions of the data series used in the paper are as follows:
Australia	Bond rates are secondary market government bond yields. The 30-day and 90-day rates are the rates on Reserve Bank bills. The policy rate is the overnight interbank rate. All are taken from the Reserve Bank of Australia's data bank.
New Zealand	Bond rates are secondary market government bond yields. The 30-day and 90-day rates are the rates on Reserve Bank bills. The policy rate is the overnight interbank cash rate. The exchange rate is the value of the New Zealand dollar in US cents. All series are from the Reserve Bank of New Zealand. The commodity price measure is an index of New Zealand import and export prices, measured in New Zealand dollars (1986 − 100). The source is ANZ Bank.
United States	Data for all Treasury securities are constant maturity rates. The policy rate is the effective federal funds rate. The data source is FRED, the database of the Federal Reserve Bank of St. Louis.
Other countries	Data for interest rates for countries other than Australia, New Zealand, and the United States (Table 2) are taken from the IMF−IFS data bank.

From the estimates in the first column of the table, it can be seen that for the whole sample, an unanticipated one-percentage point change in OCR (as measured by the same day change in the 30-day rate) changes longer term rates by an amount that declines monotonically with term to maturity. The effect ranges from 0.832 percentage points for the 1-year rate to 0.438 percentage points for the 5-year rate to 0.249 percentage points for the 10-year rate.

The estimates in column 2 of Table 5 for the sample truncated at the start of the financial crisis, show effects on longer term interest rates that differ only slightly from those in the whole sample. The estimated effect of an unanticipated one-percentage point change in OCR on the 10-year rate, for example, is 0.229 percentage points compared to 0.249 for the whole sample, approximately 2 basis points.

4.3. Estimates for Australia

Panel B of Table 5 shows estimated effects on longer term interest rates from unanticipated changes in the Australian policy rate. The sample in the first column is April 1999−August 2013. The estimate in the second column is for a sample with the same starting point but ending in August 2008.[22]

As with the estimates for New Zealand, an unanticipated one-percentage point change in the policy rate has an estimated effect on longer term rates that declines with term to maturity. For the longer sample period, the effect ranges from 0.828 for the 1-year rate to 0.349 for the 5-year rate to 0.138 for the 10-year rate. For the sample truncated in August 2008, these effects are only slightly lower (if statistically significant).

4.4. Implications for the anchoring of inflationary expectations

The estimates in Table 5 indicate that unanticipated changes in policy rate in New Zealand and Australia have statistically significant effects on longer term rates that decline monotonically with term to maturity.[23] While substantial, these effects do not appear inconsistent with inflationary expectations being well anchored in the two countries. As can be seen from the impulse responses in Figures 1 and 2 (column 1−row 1), innovations

in the policy rate exhibit a high degree of persistence in both countries. A surprise change in the policy rate would rationally be expected to persist increasing the impact on longer term rates.

The estimates in Table 5 and the impulse response functions in the previous section also bear on the question raised in the introduction of whether differences in inflation-targeting procedures in Australia and New Zealand had discernible effects on the response of long-term interest rates to monetary policy actions in the two countries. Early on the New Zealand regime was quite strict. The policy target agreement specified that the goal was a 'stable general level of prices' with an annual rise in the CPI of 0% to 2%. Bernanke, Laubach, Mishkin, and Posen (1999) wrote that 'in contrast to New Zealand's targeting framework ... the Reserve Bank of Australia emphasized flexibility in all aspects of its operations from the definition of the target to recognition of its discretion in responding to shocks' (p. 223). Over time, however, there was convergence in the procedures of the two central banks. Currently, the New Zealand policy targets agreement specifies a target rate of inflation of 1%−3% over the medium term while Australia has 'an inflation target and seeks to keep consumer price inflation in the economy to 2%−3% on an average over the medium term'.

A comparison to the effects of surprise changes of the United States policy rate provides an additional perspective. Panel C of Table 5 shows estimated effects on longer term interest rates of an unanticipated change in the United States federal funds target rate. The unanticipated change in the federal funds target rate is measured in the same way as for Australia and New Zealand, by the same day effect of the target rate change on the 30-day bill rate.[24] As can be seen from the table, the effects on longer term rates were lower in the United States than in Australia or New Zealand with the exception of the effect on the 10-year rate relative to that in Australia.[25]

The results in Table 5 appear consistent with well-anchored inflationary expectations in Australia and New Zealand over the period up to and continuing through the recent world financial crisis. The estimates do not provide evidence of better anchoring of inflationary expectations in New Zealand and Australia relative to the United States, a non-inflation-targeting country, but one with a record of low and stable inflation over the years considered.

5. Conclusion

This paper examines evidence from Australia and New Zealand on whether inflation targeting lessened the response of long-term interest rates to shocks to the monetary policy rate, thus reducing the volatility of these rates. The summary statistics in Section 2 show that the variance of longer term market interest rates declined sharply in both countries after their move to inflation targeting (at different points) in the 1990s.

Estimated VARs for the two countries show evidence of significant shifts in their coefficients pre- and post-adoption of inflation targeting. The impulse response functions presented in Section 3 indicate that estimated responses of longer term interest rates to innovations in the New Zealand and Australia policy rates declined following the introduction of inflation targeting, a finding consistent with long-term inflation expectations being more firmly anchored under inflation targeting. For New Zealand, these estimated responses decline further for the 1999−2012 period following a shift in the operating target from cash settlement balances to the interbank interest rate (OCR) in April 1999. Greater transparency resulting from the change is a plausible explanation for the change exhibited in the impulse response functions.

In Section 4, we examined the same day effect of unanticipated changes in the New Zealand and Australian policy rates. The estimated effects shown in Table 5 indicate that in both countries surprise changes in the policy rates have significant effects on longer term rates that decline monotonically with term to maturity. These effects while substantial do not seem inconsistent with inflationary expectations being well anchored in the two countries, given the persistence in the pattern of changes in the policy rate.

Impulse response functions (Figures 3 and 4) and the same-day effects of unanticipated changes in policy rates (Table 5) were also estimated for both the countries for a sample period truncated at the beginning of the financial crisis in fall 2008. These estimates differed very little from those for the full sample. There was a little indication of a weakened credibility of these inflation-targeting regimes during and after the crisis.

With respect to cross-country comparisons, overall our results do not indicate that at times stricter inflation-targeting regime in New Zealand relative to Australia has resulted in better anchored inflationary expectations. This may reflect a convergence in the regimes over the whole of our sample. The other cross-country comparisons have been made between the United States and the two inflation-targeting countries. Comparisons of the effects on longer term rates from unanticipated changes in monetary policy rates, whether measured from impulse response functions (Figures 3 and 4 compared to previous estimates for the United States) or same-day effects (Table 5, Panels A and B compared to Panel C), do not show smaller effects for the inflation-targeting countries, as might be expected had inflationary expectations been better anchored. Our results are, however, consistent with inflation-targeting regimes in Australia and New Zealand having resulted in inflationary expectations as well anchored as in the United States − a substantial change from less stable pre-inflation-targeting regimes.

Acknowledgements

Notes

1. Rogoff, Kenneth. (2005, April 23). A case for inflation transparency. *Financial Times*, p. 13.
2. Bernanke (2004, p. 166). Bernanke cites Gurkaynak, Sack, and Swanson (2005) for empirical evidence that under current Federal Reserve procedures, 'private agents' views of long-run inflation are not strongly anchored' (p. 425). English, Lopez-Salido, and Tetlow (2013) describe the Federal Reserve's subsequent move toward 'flexible inflation targeting'.
3. See also Bernanke *et al.* (1999, p. 223). There has been convergence in the interpretation of inflation targeting in New Zealand and Australia. By 2002, the Reserve Bank of New Zealand's Policy Targets Agreement specified the inflation target range as '1% to 3% over the medium term'. We will return to this question of convergence in procedures at a later point.
4. Data descriptions and sources are given in Table 6.
5. Here we date the beginning of the crisis with the Lehmann Brothers bankruptcy and AIG bailout in September of 2008. There was certainly stress in financial markets prior to this.
6. On the operation of Reserve Bank policy in the pre-2000 period of inflation targeting, see Guthrie and Wright (2000). Guender and Wu (2010) provide evidence that the change in operating procedure in 1999 increased the predictability and decreased the volatility of New Zealand interest rates at maturities out to 180 days.
7. We have also broken the sample period at the points where IT countries have started targeting inflation. For that break, New Zealand and Australia show declines in the variance of the 10-year interest rate that exceed other inflation targeters in our sample.
8. These macroeconomic variables are also subject to innovations caused by real shocks. The effects of these are not clearly affected by the change in policy regime.

9. The analysis does not extend to possible changes in the underlying error processes for the shocks and therefore to the sources of risk (or term) premia in long-term rates. Wright (2011) constructs a data set and examines term premia for 10 countries, including Australia and New Zealand, for the post-1990 period. He finds term premia to have declined globally and attributes the decline in part to 'declining inflationary uncertainty amid substantial changes in monetary policy frameworks of several central banks' (p. 1515). Bauer, Rudebusch and Wu (2014) reach somewhat different conclusions using the same data though they still find term premia declining, Wright (2014) replies.

10. The exchange rate and commodity price variables were included to control for shocks that affect interest rates in addition to monetary policy. The selection of commodity prices rather than consumer prices is due to the unavailability of monthly data for the consumer price index for both countries for our sample period. Commodity prices are highly correlated with consumer prices. The correlation coefficients (quarterly log-levels) for Australia and New Zealand are 0.98 and 0.66, respectively, for the whole sample.

11. To save space, we do not include tables of unit root tests.

12. The test was originally proposed in Chow (1960). For the application to VARs, see Canova (2007).

13. The VAR specifications were also estimated with a time trend included. The pattern of impulse responses is robust to this change.

14. Confidence bands for the estimated impulse responses are calculated using a bootstrap method of 2000 draws to compute the standard errors.

15. The level of significance is 5% throughout the analysis of impulse response functions.

16. The effect on the commodity price index for a small country such as New Zealand would be expected to be only via the effect on the exchange rate. The positive effect is consistent with the negative effect on the exchange rate. Still both the effects are counter intuitive. Both reflect the 'exchange rate puzzle' as discussed in Kim and Roubini (2000) and Chen and Rogoff (2002).

17. Data for the 2-year interest rate for Australia do not go far enough back to estimate the VAR for the pre-inflation targeting period. Thus, the 1×1 cell in Figure 4 is blank.

18. A specific comparison is to results from VAR analyses for the United States summarized in Berument and Froyen (2009, Table 1). An update of these estimates to provide evidence on changing responses of long-term rates to change in the federal funds rate is precluded by the fact that since December 2008 the target federal fund rate has been at the effective lower bound of 0.25%.

19. An interbank rate futures market does exist for Australia. The data does not extend far enough back for our purposes. Moreover, that approach would complicate comparisons to the New Zealand experience. Smales (2012) investigates the response of interest rate futures to Reserve Bank of Australia target rate announcements for the period 2004−2010.

20. See Guender and Rimer (2008) for a detailed description of the Reserve Bank's procedures.

21. Note that the policy variable here is the official cash rate rather than the actual overnight cash rate. Discrete policy changes are changes in that rate. Definitions and data sources for all interest rates are given in Table 6.

22. These sample periods are chosen for purposes of comparison with New Zealand. Estimates that begin with the adoption of inflation targeting in October 1994 have quite similar implications to those in Table 5.

23. In the case of Australia, these effects also lose statistical significance at longer terms to maturity.

24. The Federal Reserve announces changes in the target federal funds rate in the early afternoon before the bond markets close. Therefore, here the changes in the market rates are from day $(t − 1)$ to (t), when t is the date of the target rate change. The sample period for the United States in Table 5 ends in August 2008 for purposes of comparison. If the sample is extended to December of 2008 when the federal funds rate hits the effective zero bound, the responses of longer term interest rates are higher. They are still lower than in Australia or New Zealand for 2-, 5- and 10-year rates.

25. Swiston (2007); Table 1) studies the United States for the period March 2000−June 2006 using the method of Kuttner (2001) which relies on data from the federal funds futures market to measure unanticipated changes in the federal funds target rate. His estimates of the effect on longer term market interest rates of surprise changes in the policy rate are quite similar to those in Table 5 (Panel C), especially for longer maturities.

References

Ball, L. (2011). The performance of alternative monetary regimes. In Benjamin M. Friedman, & Michael Woodford (Eds.), *Handbook on monetary economics* (pp. 1303−1343). Amsterdam: Elsevier.

Ball, L., & Sheridan, N. (2005). Does inflation targeting matter? In Ben S. Bernanke & Michael Woodford (Eds.), *The inflation targeting debate* (pp. 249−276). Chicago, IL: University of Chicago Press.

Bauer, M.D., Rudebusch, G.D., & Wu, J.C. (2014). Term premia and inflation uncertainty: Empirical evidence from an international panel dataset. *American Economic Review, 104*, 323−337.

Bernanke, B.S. (2004). Inflation targeting. *Federal Reserve Bank of St. Louis Review, 86*, 165−168.

Bernanke, B.S., Laubach, T., Mishkin, F., & Posen, A.S. (1999). *Inflation targeting*. Princeton, NJ: Princeton University Press.

Berument, H., & Froyen, R. (2006). Monetary policy and long-term U.S. interest rates. *Journal of Macroeconomics, 28*(4), 737−751.

Berument, H., & Froyen, R. (2009). Monetary policy and U.S. long-term interest rates: How close are the linkages? *Journal of Economics and Business, 61*(1), 34−50.

Canova, F. (2007). *Methods for applied macroeconomic research*. Princeton, NJ: Princeton University Press.

Chen, Y., & Rogoff, K. (2002). *Commodity currencies and empirical exchange rate puzzles* (IMF Working Paper 02/27). Washington, DC: IMF.

Chow, G. (1960). Tests for equality between sets of coefficients in two linear regressions. *Econometrica, 28*(3), 591−605.

Cochrane, J.H., & Piazzesi, M. (2002). The fed and interest rates − a high-frequency identification. *American Economic Review, 92*(2), 90−95.

Dueker, M.J., & Fischer, A.M. (2006). Do inflation targeters outperform non-targeters? *Federal Reserve Bank of St. Louis Review, 88*(5), 431−450.

Ellingsen, T., Söderström, V., & Masseng, L. (2004). *Monetary policy and the bond market* (Working Paper). Stockholm, Sweden: Stockholm School of Economics.

English, W.B., Lopez-Salido, J., & Tetlow, R. (2013). *The Federal Reserve's framework for monetary policy: Recent changes and new questions*. Finance and Economics Discussion Series. Washington, DC: Board of Governors of the Federal Reserve System.

Evans, C.L., & Marshall, D.A. (1998). Monetary policy and the term structure of nominal interest rates: Evidence and theory. *Carnegie Rochester Series on Public Policy, 49*, 53−111.

Guender, A.V., & Rimer, O., (2008). The implementation of monetary policy in New Zealand: What actions affect the 90-day bank bill rate? *North American Journal of Economics and Finance, 19*, 215−234.

Guender, A.V., & Wu, A.G., (2010). Operating procedures and the expectations theory of the term structure of interest rates: The New Zealand experience from 1989 to 2008. *Applied Financial Economics, 22*(14), 1181−1192.

Gurkaynak, R.S., Sack, B., & Swanson, E. (2005). The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American Economic Review, 95*(1), 425−436.

Guthrie, G., & Wright, J. (2000). Open mouth operations. *Journal of Monetary Economics, 46*, 489−516.

Kim, S., & Roubini, N. (2000). Exchange rate anomalies in the industrial countries: A solution with a structural VAR approach. *Journal of Monetary Economics, 45*, 561−586.

Kuttner, K.N. (2001). Monetary policy surprises and interest rates: Evidence from the fed funds futures market. *Journal of Monetary Economics, 47*(3), 523−544.

Levin, A.T., Natalucci, F.M., & Pizer, J.M. (2004). The macroeconomic effects of inflation targeting. *Federal Reserve Bank of St. Louis Review, 86*(4), 51−80.

Lutkepohl, H., & Reimers, H. (1992). Impulse response analysis of co-integrated systems. *Journal of Economic Dynamics and Control, 16*, 53−78.

Mishkin, F., & Schmidt-Hebbel, K. (2007). *Does inflation targeting make a difference?* (NBER Working Paper 12876). Cambridge, MA: NBER.

Pesaran, M.H., & Shin, Y. (1998). Generalized impulse response analysis in linear multivariate models. *Economic Letters, 58*, 17−29.

Sims, C.A., Stock, J.H., & Watson, M.W. (1990). Inference in linear time series models with unit roots. *Econometrica, 58*, 113−144.

Smales, L.A. (2012). RBA monetary policy communication: The response of Australian interest rate futures to changes in RBA monetary policy. *Pacific-Basin Finance Journal, 20*, 793−808.

Swiston, A. (2007). *Where have the monetary surprises gone? The effects of FOMC statements* (IMF Working Paper WP/07/185). Washington, DC: IMF.

Wright, J.H. (2011). Term premia and inflation uncertainty: Empirical evidence from an international panel dataset. *American Economic Review, 100*, 1514−1534.

Wright, J.H. (2014). Term premia and inflation uncertainty: Empirical evidence from an international panel data set. *American Economic Review, 104*, 338−341.